Supersonics Project—Airport Noise Tech Challenge

The Airport Noise Tech Challenge research effort under the Supersonics Project is reviewed. While the goal of "Improved supersonic jet noise models validated on innovative nozzle concepts" remains the same, the success of the research effort has caused the thrust of the research to be modified going forward in time. The main activities from FY06-10 focused on development and validation of jet noise prediction codes. This required innovative diagnostic techniques to be developed and deployed, extensive jet noise and flow databases to be created, and computational tools to be developed and validated. Furthermore, in FY09-10 systems studies commissioned by the Supersonics Project showed that viable supersonic aircraft were within reach using variable cycle engine architectures if exhaust nozzle technology could provide 3-5dB of suppression. The Project then began to focus on integrating the technologies being developed in its Tech Challenge areas to bring about successful system designs. Consequently, the Airport Noise Tech Challenge area has shifted efforts from developing jet noise prediction codes to using them to develop low-noise nozzle concepts for integration into supersonic aircraft. The new plan of research is briefly presented by technology and timelines.

Supersonics Project—Airport Noise Tech Challenge
Acoustics Technical Working Group—Fall 2010
James Bridges, NASA Glenn Research Center

Supersonic Project Technical Elements

Cruise Efficiency
- Tools and technologies for integrated propulsion and vehicle systems level analysis and design
- High performance propulsion components
- Low Boom / Low Drag design

Airport Noise
- Improved supersonic jet noise models validated on innovative nozzle concepts

Sonic Boom Modeling
- Realistic propagation models
- Indoor transmission and response models

Aero-Propulso-Servo-Elasticity
- ASE/flight dynamic and propulsion analysis and design tool development and validation
- APSE analysis and design tools

High Altitude Emissions
- Improved prediction tools
- Low emissions combustors

Light Weight and Durability at High Temperature
- Materials, test and analysis methods for airframe and engine efficiency, durability and damage tolerance

Airport Noise Elements FY06-FY10

- Prediction
  - MDOE Empirical Tool
  - CFD-Based Noise Codes
  - Time-Resolved LES/CAA
- Diagnostics
  - Turbulence Statistics for Prediction Codes
  - Supersonic Aeroacoustic Databases ✧
  - Phased Arrays
- Engineering
  - Shock Modification-Air Injection (N+1)
  - Offset Stream Nozzles (N+1)
  - Highly Variable Cycle (HVC) Nozzle (N+1) ✧
  - Tactical Aircraft Chevron Nozzles (N+1)
  - Iconic Supersonic Vehicle—High Aspect Ratio Nozzles (N+2) ✧
  - Unsteady Jet Control using Plasma Actuators (N+3) ✧

Supersonics:Airpor
t Noise

Extensible Rectangular Nozzle Tests

- Family of high aspect ratio nozzles
- AR=2:1, 4:1, 8:1
- Basic Rectangle +
  - Bevel
  - Cutback
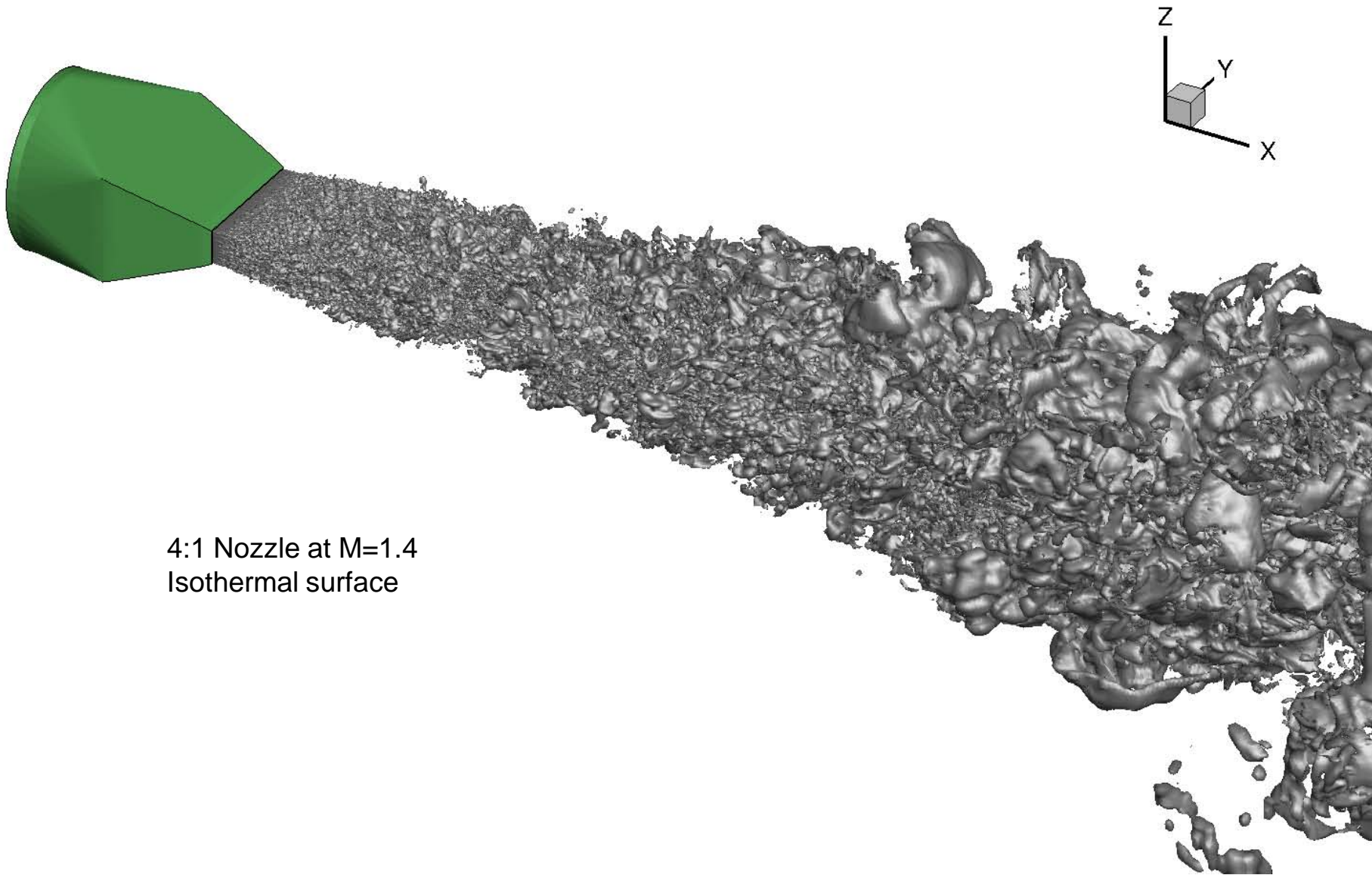 - Chevrons
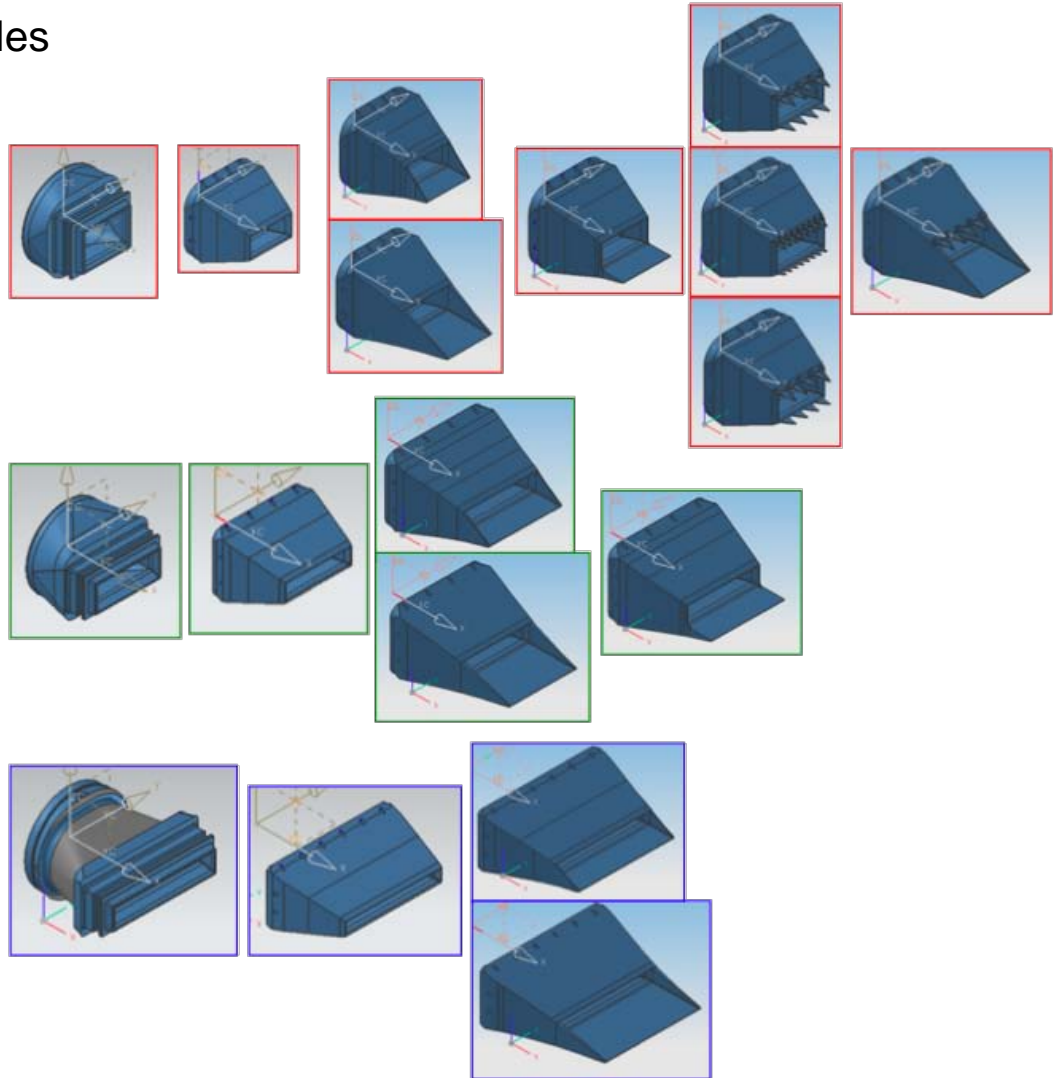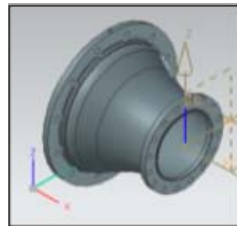
Extensible Rectangular Nozzle Status

- Delivery 17 Nov
- Test in December
  - Far-field acoustics
  - Phased array

Extensible Rectangular Nozzle—Stanford LES
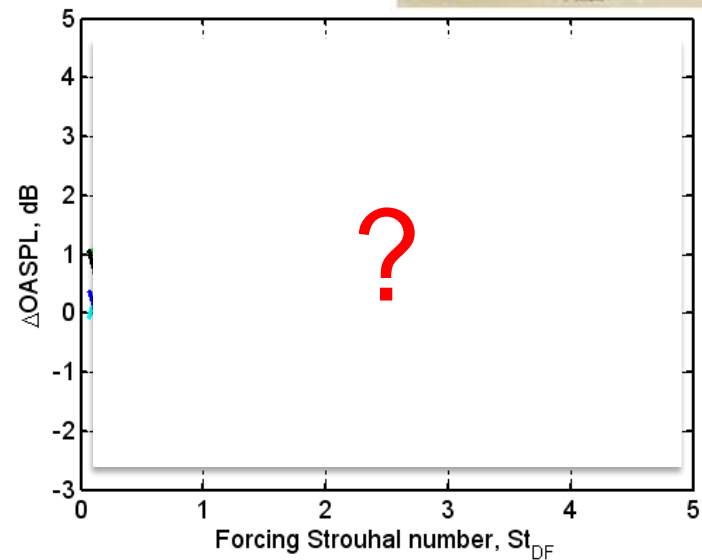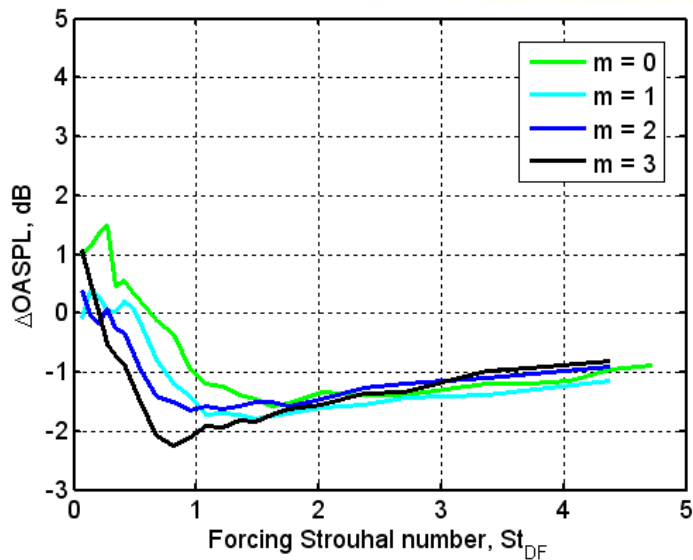
4:1 Nozzle at M=1.4
Isothermal surface

Unsteady Control using Plasma Actuators—Scale-up Test

- OSU
- 1" nozzle
- 8 actuators
- -3 < m < 3

- NASA NATR
- 6.5" nozzle
- 60 actuators
- -8 < m < 8
- Efficient electronics!

?
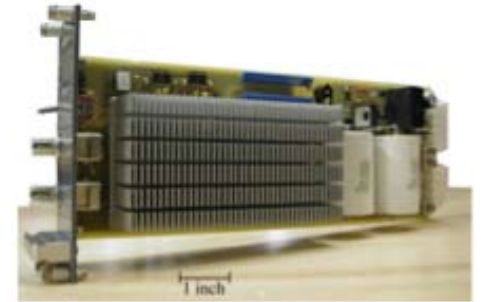
Supersonic Project Evolution

Cruise Efficiency
Sonic Boom Mitigation

Environmental Challenges - No greater impact than subsonic fleet

Airport Noise

Sonic Boom Modeling

System Design for Low Boom while meeting Challenges

Aero-Servo-Elastic Analysis and Design

High Altitude Emissions

Light Weight and Durability at High Temperature

Efficiency Challenges - 30 % Improvement over HSR

Synopsis: Airport Noise—FY06-FY10

- Success in Airport Noise research has enabled a new generation of noise prediction tools

- Development of LES puts it in league of research design tool

- RANS-based codes need wider validation, e.g. more 3D

- Many concepts fail because implementation is flawed, need application of CFD from beginning.

- Have new framework for making predictions available to Systems Integration Discipline—ANOPP2

Synopsis: Systems Analysis Studies

- Both N+2 and N+3 studies reached same broad conclusions

    - Successful systems are possible with engine cycles near current civil engines.

    - Jet noise major constraint on engine diameter, weight, thus boom.

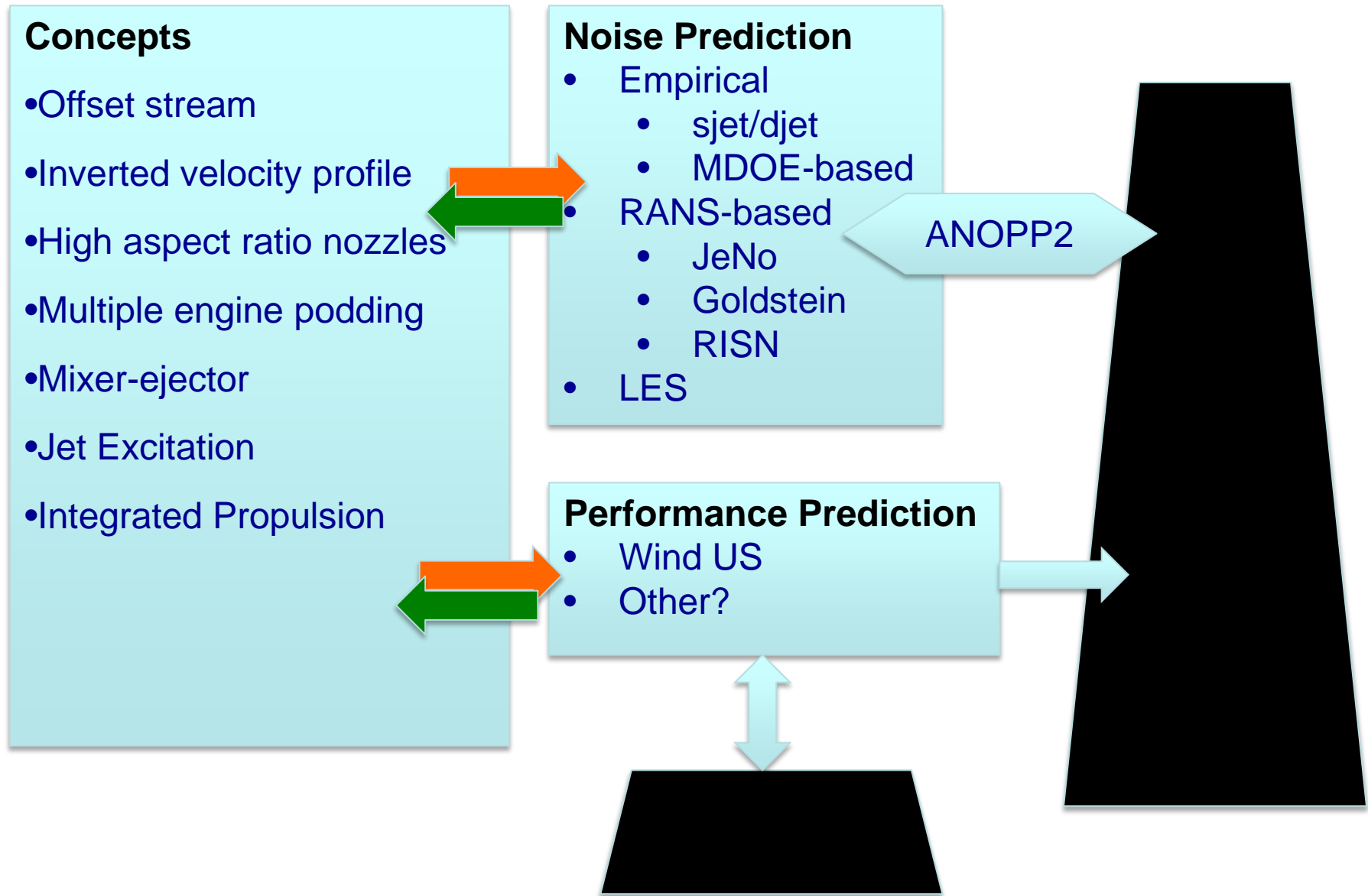   - Fan noise may be problem, especially with distorted inlet flow.

Airport Noise Response for Future

- Need ~3-5dB jet noise reduction technologies applicable to Study vehicles

  - Trade for sonic boom and performance.

  - Monitor fan noise (distorted inlet flow); airframe noise (high lift).

- Refocus flow physics regime

  - No mach wave emission-specific codes

  - Reduce emphasis on shock noise reduction concepts

- Use and validate design tools for jet noise and performance on low-noise concepts.

  - Use experimental tools to validate concepts and design tools.

  - Use concepts to motivate tool development.

- Carry through concept investigations to ANOPP2 module, ready for Systems Integration and Analysis

FY11-15 Airport Noise Strategy

Concepts

- Offset stream

- Inverted velocity profile

- High aspect ratio nozzles

- Multiple engine podding

- Mixer-ejector

- Jet Excitation

- Integrated Propulsion

Noise Prediction
- Empirical
  - sjet/djet
  - MDOE-based
- RANS-based
  - JeNo
  - Goldstein
  - RISN
- LES

ANOPP2

Performance Prediction
- Wind US
- Other?

FY11-15 Airport Noise Activities

Concepts	Tools			
	Experimental	Empirical	RANS-based	LES
• Offset stream	🟢	🟡🟢	🟡🟢	
• Inverted velocity profile	🟡🟢	🟡🟢	🟢	
• High aspect ratio nozzles	🟢	🟡	🟡🟢	🟡🟢
• Multiple Jets	🟡🟢	🟡🟢	🟡🟢	
• Mixer-ejector	🟡🟢	🟡🟢	🟡	
• Jet Excitation	🟡🟢	🟡	🟡	🟡🟢
• Integrated Propulsion	🟡	🟡	🟡🟢	🟡

Tool Development Scale

Needs Development	Ready

Airport Noise Tech Challenge Level 3 Milestones & Activities

	FY11	FY12	FY13	FY14	FY15	FY16

Develop Concepts

Fan vanes · High aspect ratio nozzles · Mixer-ejector · Integrated Nozzle

IVP+Fluid Shield · Multijet · Excited Jet

Level 3 Milestones

L2 Milestone Integrated Low Noise Nozzle Validation

Develop Tools

- djet Valdation
- MDOE · MDOE · MDOE · MDOE · MDOE · MDOE · MDOE
- RANS for BBSN
- Non-Axisymmetric Green's Fn
- 3D vector Green's Fn solver
- Practical LES
- Near-Jet CAA

Airport Noise Elements FY06-FY10

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  - Supersonic Aeroacoustic Databases
  - Phased Arrays

    Twin Jet Experiment

- Engineering
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  - Offset Stream Nozzles (N+1)
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    HVC10 Test

  - Tactical Aircraft Chevron Nozzles (N+1)
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  - Unsteady Jet Control using Plasma Actuators (N+3)

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